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ABSTRACT

This issue of "Policy Forum" compares the mathematics and science achievement of students midway through elementary school, midway through lower secondary school, and at the end of upper secondary school. The Third International Mathematics and Science Study (TIMSS), conducted in 1995-96, is the largest international education study ever undertaken with data from one-half million students in 41 nations. The featured article provides significant research findings from TIMSS on student achievement, curriculum, and teaching, and discusses implications for policy and practice. The concept of benchmarking is reviewed in a sidebar. Information on how to access the U.S. Department of Education, the two Research and Development (R&D) Centers funded by this institute, and a variety of TIMSS Web sites are also provided. (ASK)

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A Wake-Up Call for U.S. Educators: The Third International Mathematics and Science Study

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THE POLICY FORUM

National Institute on Educational Governance, Finance, Policymaking, and Management

A Wake-Up Call for U.S. Educators: The Third International Mathematics and Science Study

The Third International Mathematics and Science Study (TIMSS) is the largest international education study ever undertaken with data from one-half million students in 41 nations. Conducted in 1995–96 under the auspices of the International Association for the Evaluation of Education Achievement (IEA), it is also one of the most rigorous and comprehensive international studies.

TIMSS compares the mathematics and science achievement of students midway through elementary school, midway through lower secondary school, and at the end of upper secondary school. In the United States, we tested over 33,000 students in more than 500 schools in the 4th, 8th, and 12th grades. As well as content assessments, there were curriculum analyses, teacher surveys, and a video study of teaching in three countries.

Significant Research Findings

TIMSS offers significant findings in three key areas: student achievement, curriculum, and teaching.

Student Achievement. American school children were the only students with above average scores in 4th grade to lose ground in the 8th by testing average, and then to do worse again in the 12th. By the time our students had moved through our education system they were among the lowest scoring students in the study.

The 4th-grade achievement of American students is quite high. Our students are near the top in both mathematics and science. Of the 25 participating countries, our 4th-graders were outperformed in science only by Korea; showed no significant difference with 5 other countries; and outperformed 19 other countries. In mathematics, our 4th-graders were outperformed by 7 countries; 6 countries were not significantly different; and our students did better than 12 nations.

In middle school (8th grade in the United States), 41 countries participated. While our students were above the international average in science, they were below the international average in mathematics. American students were outperformed in science by 9 nations; performed similarly to 17 nations; and outperformed 15 nations. Twenty nations outperformed American students in 8th-grade mathematics; 14 performed at the same level; and 7 nations fell below our students.

In a pattern similar to 4th and 8th grade, the United States' 12th-grade international standing in science is higher than in mathematics. However, both U.S. science and mathematics performances are below the international average and among the lowest of the 21 TIMSS countries. In science, students in 11 countries outperformed American students; students in 7 countries performed similarly to American students; and American students outperformed students in only 2 countries. In mathematics, American 12th-graders performed below the international average and among the lowest of the 21 TIMSS countries. American students were outperformed by 14 countries; were not different than 4 countries; and outperformed students in 2 countries. Even our best mathematics and science students did not fare well in comparison with the best mathematics and science students from other countries.

Curriculum. There are no required national curriculum standards in the United States. Curriculum standards are developed and maintained at various levels of government—local, state, and national. The TIMSS curriculum studies were conducted by researchers at Michigan State University. It appears that U.S. mathematics and science curricula lack the coherence, focus, and rigor of the curricula taught in other countries that participated in TIMSS. Most state curriculum frameworks emphasize breadth over depth.

(Continued on page 6)

What Is Benchmarking?

While benchmarking is unfamiliar to most educators, it has been successfully used in business to foster continuous improvement and achieve excellence. Benchmarking can help organizations—including schools, districts, and state agencies—become high performance learning communities.

Benchmarking is an *activity* where organizations continuously engage in self-study and compare themselves with the leaders in their field so they can identify, adapt, and apply significantly better practices.

It is a systematic, evidence-based, and participatory change process. Benchmarking may be done at the strategic level where the goal is to create a shared vision and identify key levers for organizational change. If the strategic thinking has already been done, then benchmarking can take place at the level of specific practices or processes (e.g., improve curriculum or professional development).

The benchmarking process includes the following steps:

- **Self-assessment.** Document and study your own organization's vision, practices, and success measures. Decide *what* to benchmark.
- **Comparison.** Decide *who* to benchmark. Identify exemplars and establish a benchmarking partnership. Study and assess your partner(s). For example, in the areas of mathematics and science education, you can use local exemplars as well as TIMSS data for comparison purposes.
- **Analysis and Adaptation.** Ask *why* you are getting your results and why others are getting better results. While benchmarking is often called "borrowing shamelessly," practices generally require creative adaptation in a new context.
- **Implementation.** Think carefully about what enablers (e.g., resources, schedule changes) are needed. Communicate findings and build support for the changes you want to make.
- **Feedback.** Carefully monitor and measure the results of your innovation and recalibrate if necessary.

Benchmarking Resources

Read more about the benchmarking process. These references were used as sources for this article.

Tucker, Sue. 1996. *Benchmarking: A Guide for Educators.* Thousand Oaks, CA: Corwin Press. A brief introduction adapted for educators in a clear "how to" format.

Resnick, Lauren B. and Nolan, Katherine J. 1995. "Benchmarking Education Standards." *Education Evaluation and Policy Analysis,* 17(4), 438–61. An example of an international benchmarking study in education.

Bogan, Christopher E. and English, Michael J. 1994. *Benchmarking for Best Practices: Winning through Innovative Adaptation.* New York: McGraw Hill. An in-depth treatment written for the business context.

Watson, Gregory H. 1993. *Strategic Benchmarking: How to Rate Your Company's Performance Against the World's Best.* New York: John Wiley and Sons. A classic in the field.

Use existing data for international benchmarks in math and science education.

Government Printing Office, 1997. *Attaining Excellence: A TIMSS Resource Kit.* Designed to help educators use TIMSS, the kit contains multimedia materials including reports, videotapes, and discussion overheads. It includes four modules: overview, achievement, curriculum, and teaching. Call GPO at (202) 512–1800 to purchase the whole kit in a carry-case box for $94. (Modules also available separately.) The kit can also be downloaded free from the Internet (*see p. 4*).

Stigler, James W. and Stevenson, Harold W. Spring 1991. "How Asian Teachers Polish Each Lesson to Perfection," *American Educator,* 12–20, 43–47. This article compares key features of elementary school mathematics lessons in Taiwan, Japan, and the United States. With a related 34-minute videotape depicting classroom scenes, these materials may be used to introduce international benchmarking to a variety of audiences, especially elementary mathematics teachers. The videotape may be ordered by sending a check for $35 to the University of Michigan, c/o Mrs. S. Liang, 30 N. Ingalls, 10th Floor, Ann Arbor, MI 48109.

TIMSS: A "Power Tool" for School Reform

In October 1997, the National Institute on Educational Governance, Finance, Policymaking, and Management sponsored a TIMSS Policy Forum to explore the practical uses of TIMSS. These interviews with a few Forum participants illustrate how TIMSS may be used by state agencies, school districts, professional associations, and researchers.

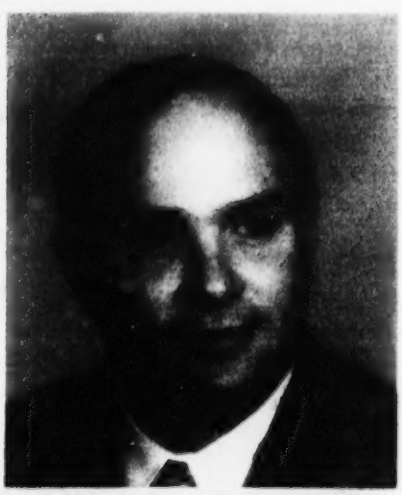
Susan Zelman, Deputy Commissioner, Department of Elementary and Secondary Education, Missouri

We want to move toward a new educational paradigm in Missouri. Our vision is to replace classrooms where teachers talk and students passively listen with classrooms where teachers facilitate hands-on learning activities and students learn to think and apply their knowledge.

As we pursue this goal, we have used TIMSS to strengthen our state assessment program and to enhance our professional development efforts.

We administered the TIMSS test to about 12,000 students. The test results were used for a content validation of the eighth-grade mathematics test in our Missouri Assessment Plan. We also used the TIMSS test results to benchmark our curriculum. It helped us identify specific areas where we were doing well and others where we needed to improve. Also, we found the attitudinal data on teachers and students very helpful. For example, data on why students think they succeed offers insight about student motivation.

Professional development is a key reform strategy in Missouri. We have established nine regional professional development centers based in state colleges and universities where we train lead teachers in authentic instruction and assessment methods. The TIMSS materials, especially the videos, have been used successfully with teachers in our centers.



Paul Kimmelman, Superintendent, West Northfield School District #31 in Illinois and President, First in the World Consortium

The First in the World Consortium was created 3½ years ago and now includes 19 suburban Illinois school districts. Our Consortium is deeply committed to National Education Goal #5—becoming first in the world in mathematics and science. Because we saw the potential of benchmarking with TIMSS as an important means to our ambitious goal, we formed a partnership with the U.S. Department of Education which enabled us to participate in TIMSS as if we were a country. A total of 3,100 students were tested representing a student population of 37,000.[1]

Now we are creating learning communities to study the TIMSS results and compare our achievement with other countries. The rich data about curriculum and teaching are generating ideas for improved practice in our districts. We have supported two summer institutes with 350 participants, including teachers, administrators, and school board members. This year, institute participants will develop curriculum products that exemplify new concepts of teaching and learning in math and science. Throughout the year, teachers across our districts are involved in learning networks which support collaboration around curriculum development based on our TIMSS data.

We have partnered with the North Central Regional Educational Laboratory (NCREL) for assistance in planning, documenting, and disseminating our activities. Further information about our consortium is available on the Internet (*http://www.ncrel.org*).

[1]Editor's Note: The National Center for Education Statistics has made it possible through the ***1999 TIMSS Benchmarking for States and Districts*** study for more states and school districts to participate directly in international benchmarking. This spring about 30 states, districts, and/or consortia will collect data that will enable comparisons with 40 countries.

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Alice Gill, Associate Director, Educational Issues Department, American Federation of Teachers (AFT)

TIMSS is very important at AFT because it supports our long-standing emphasis on high standards. We see it as a valuable tool for benchmarking U.S. teaching practices, curriculum, and educational policy with the best in the world. We have developed an AFT "TIMSS Kit" to help our members understand what the findings say and what they don't say. We also have incorporated the data and the videotape into our "Thinking Mathematics" research synthesis and professional development for elementary and middle school teachers.

We have introduced thousands of teachers and union leaders to the TIMSS materials at various meetings, including the "Lessons from the World" TIMSS Conference that AFT co-sponsored with the National Center for Education Statistics in February 1997, the Summer and Winter Institutes of the Educational Research and Dissemination Program, and regional meetings for "Thinking Mathematics" teacher leaders. These members, in turn, disseminate the findings to many other groups.

Teachers find the TIMSS videotape study extremely useful as a focus for improving their mathematics and science lessons. They use it, for example, to examine the level of challenge in their questioning, the coherence of their lessons, and the focus and content of their curricula. Videotape is a powerful tool for reflection and the TIMSS data are rich with information beyond the "horse race."

Susan Fuhrman, Director, Consortium for Policy Research in Education (CPRE), University of Pennsylvania

Photo courtesy of Tommy Leonardi

The TIMSS data offer exciting opportunities for educational researchers. I can see at least four important lines of inquiry these data can support: multivariate analyses of factors contributing to student achievement; cross-national research, especially in the areas of curriculum, instruction, and assessment; studies of effective strategies for improving math and science education; and in-depth studies of teaching practice, an area where TIMSS exemplifies significant methodological advances.

At the University of Pennsylvania, we are already engaged in TIMSS-related research. With Office of Educational Research and Improvement (OERI) and National Science Foundation (NSF) funding, we will be conducting a comprehensive multivariate analysis to address this question: Why did American 8th- and 12th-graders perform so poorly on TIMSS science and math tests, and why was there such a sharp deterioration of performance from the 4th- to 12th-grades? Also with OERI funding, CPRE is sponsoring three TIMSS Forums between February 1999 and June 2001 to help identify important issues for the next iteration of this international study and to facilitate dissemination of information from this round.

—Norma Fleischman of the Institute staff contributed to this article.

Publication Available

For those who would like more information about our TIMSS Policy Forum, a free booklet summarizing the discussion is available. Call (877) 4ED-PUBS (877–433–7827) and ask for *Policy Brief: What the Third International Mathematics and Science Study (TIMSS) Means for Systemic School Improvement.* Also look for it on the Internet ***(http://www.ed.gov/pubs/edpubs.html).***

WWW. Education Research

As schools and other education organizations "get wired" and researchers put their findings on the Web, the Internet may help close the gap between education research and practice. Many of our readers have expressed an interest in getting education research on the Internet. Information on how to access the U.S. Department of Education, the two R&D Centers funded by this Institute, and a variety of TIMSS Web sites follows. Enjoy surfing!

U.S. Department of Education (ED) has a home page (***http://www.ed.gov***). It offers a wide variety of information about federal education programs, priorities, and events. To get information specifically about research, statistics, and assessment, go to the blue sidebar on the left and click on "Research and Statistics." Scroll down the page and you will see the National Institute on Educational Governance, Finance, Policymaking, and Management listed under "Research Institutes" (along with the four other Institutes). By clicking on our name, you can get information about us or you can link to the home pages of the two national R&D Centers we fund which are described below.

Consortium for Policy Research in Education (CPRE), a grantee of this Institute, recently expanded its Web site which features policy research. Highlights include: center mission and participating universities, detailed information about current CPRE research projects, publications information, case studies, and a "paper of the month." CPRE Policy and Finance Briefs can be downloaded. You can access the Web site directly at ***http://www.upenn.edu/gse/cpre*** or contact Robb Sewell at (215) 573–0700, ext. 225 for further details.

Center for the Study of Teaching and Policy (CTP) recently received a grant from this Institute to investigate the relationship between excellent teaching and policymaking. The Center's research is still in the beginning stages, but information about findings will be added as it becomes available. Information about the Center's mission and research plans is on their Web site. The address is ***http://depts.washington.edu/ctpmail*** or for further information contact Michele Ferguson at (206) 221–4114.

Third International Mathematics and Science Study (TIMSS) information can be obtained through the main ED Web site described above or use ***http://nces.ed.gov/timss*** for direct access. Here you can download the major TIMSS 4th-, 8th-, and 12th-grade studies. For additional information, call the TIMSS Customer Service Line at (202) 219–1333.

Several nongovernment Web sites also offer information about TIMSS.

International Association for the Evaluation of Educational Achievement has information about TIMSS as well as other international studies on such topics as technology and reading (***http://www.iea.nl/***).

Boston College provides links to a variety of other TIMSS Web sites in the United States and other nations (***http://www.csteep.bc.edu/Timss1/TIMSSSites.html***) and also has details about the TIMSS database, including data files, questionnaires, and database user guides (***http://www.csteep.bc.edu/timss1/database.html***).

Michigan State University has information about the TIMSS curriculum study (***http://ustimss.msu.edu/***).

Eisenhower National Clearinghouse is the source for the TIMSS Resource Kit which can be downloaded for free. In addition to TIMSS information, this site includes other tools useful for benchmarking as well as national and state standards documents (***http://timss.enc.org/***).

Please send your comments and suggestions for the newsletter to:

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(A Wake-Up Call, continued from page 1)

Mathematics and science textbooks in the United States were found to be substantially longer than the international average and to express the incoherence, fragmentation, and lack of rigor noted in the U.S. curriculum.[1]

Teaching. The 8th-grade mathematics videotape classroom study conducted in the United States, Germany, and Japan found American and German lessons, unlike Japanese lessons, to focus primarily on the acquisition and application of skills rather than problem solving and thinking. When mathematical concepts are addressed, three-fourths of Japanese and German teachers developed the concepts after introducing them compared to less than one-fifth of American teachers. American teachers tend only to state rather than develop concepts. There was less cohesion in American versus Japanese lessons. The average grade level of 8th-grade mathematics taught in the United States was 7.4 versus 8.7 in Germany and 9.1 in Japan. While 62 percent of Japanese and 21 percent of German 8th-grade mathematics lessons included deductive reasoning, no American lessons did.

Lesson plans from each country (with national origin disguised) were judged by an independent group of American college mathematics teachers. Eighty-nine percent of American lessons were found to be of low quality and none were judged to be of high quality. In comparison, 11 percent of Japanese lessons and 34 percent of German lessons were found to be of low quality, and 39 percent of Japanese lessons and 28 percent of German lessons were judged to be of high quality.

[1]Schmidt, W.H., McKnight, C.C., and Raizen, S.A., et al. 1997. *The Splintered Vision: An Investigation of U.S. Science and Mathematics Education.* Norwell, MA: Kluwer Academic Publishers.

Implications for Policy and Practice

TIMSS is not an answer book, but it does provide us a new lens through which to view our education system. These findings challenge aspects of American education that we have previously taken for granted and force us to reevaluate our cultural assumptions about educational excellence. By comparing our education system to those of other countries, we better understand ourselves. Careful reflection on our education system within this international perspective can provide valuable insights for educators, teachers, parents, and business leaders as we move our nation forward in the pursuit of educational reform.

Obviously, we have much work to do to improve student achievement in the upper grades. We do give our students a good start, but we must urgently ask ourselves why U.S. students lose the lead as they are presented more complex mathematics and science content after grade four. We cannot afford to be complacent about our curriculum and teaching practices. The TIMSS data warn that our benchmarks in these areas need to be much higher. Reformers who choose to use the information available in TIMSS for benchmarking toward higher standards have an unprecedented opportunity to improve American mathematics and science education .

—Douglas Cochrane, Education Statistics Services Institute.

Editor's Note: TIMSS was initiated and funded primarily by the National Center for Education Statistics (NCES), with supplementary support for international coordination from the National Science Foundation (NSF) and the Canadian Government.

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